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(54) **CONTROLLER FOR CONTROLLING A POWER CONVERTER TO OUTPUT CONSTANT POWER AND RELATED METHOD THEREOF**

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315/219, 291, 307, 308, 362

See application file for complete search history.

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H02M 3/24 (2006.01)
H02M 1/00 (2007.01)

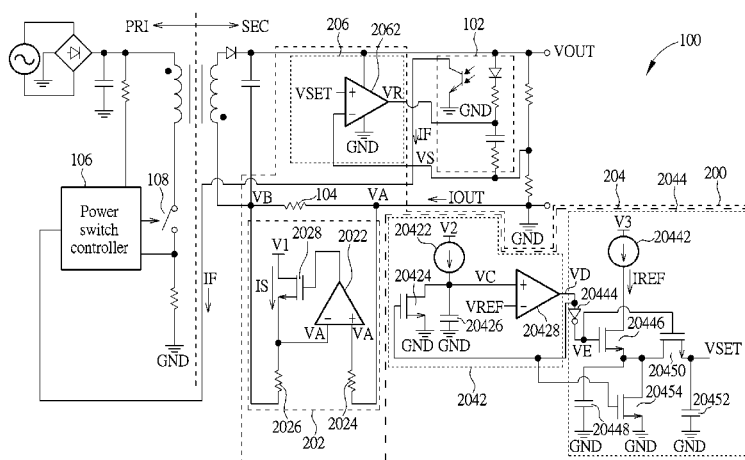
(52) **U.S. Cl.**
CPC **H02M 3/24** (2013.01); **H02M 3/33507** (2013.01); **H02M 2001/0019** (2013.01)

(58) **Field of Classification Search**
CPC H02M 3/24; H02M 3/33523; H02M 3/33507; H02M 2001/0009; G05F 1/46; G05F 1/462; G05F 1/468; G05F 1/575; G05F 1/66; G05F 5/00

(57) **ABSTRACT**

A controller for controlling a power converter to output constant power includes a current sensing module, a voltage generation module, and a voltage regulation module. The current sensing module generates a sensing current according to an output current flowing through a secondary side of the power converter. The voltage generation module generates a set voltage corresponding to a reciprocal of the sensing current according to the sensing current. The voltage regulation module generates a regulation voltage to a feedback circuit of the secondary side of the power converter according to the set voltage and a sensing voltage corresponding to an output voltage of the secondary side of the power converter. The feedback circuit and a primary side of the power converter regulate the output voltage according to the regulation voltage, where a product of the output voltage and the output current is a constant value.

14 Claims, 3 Drawing Sheets



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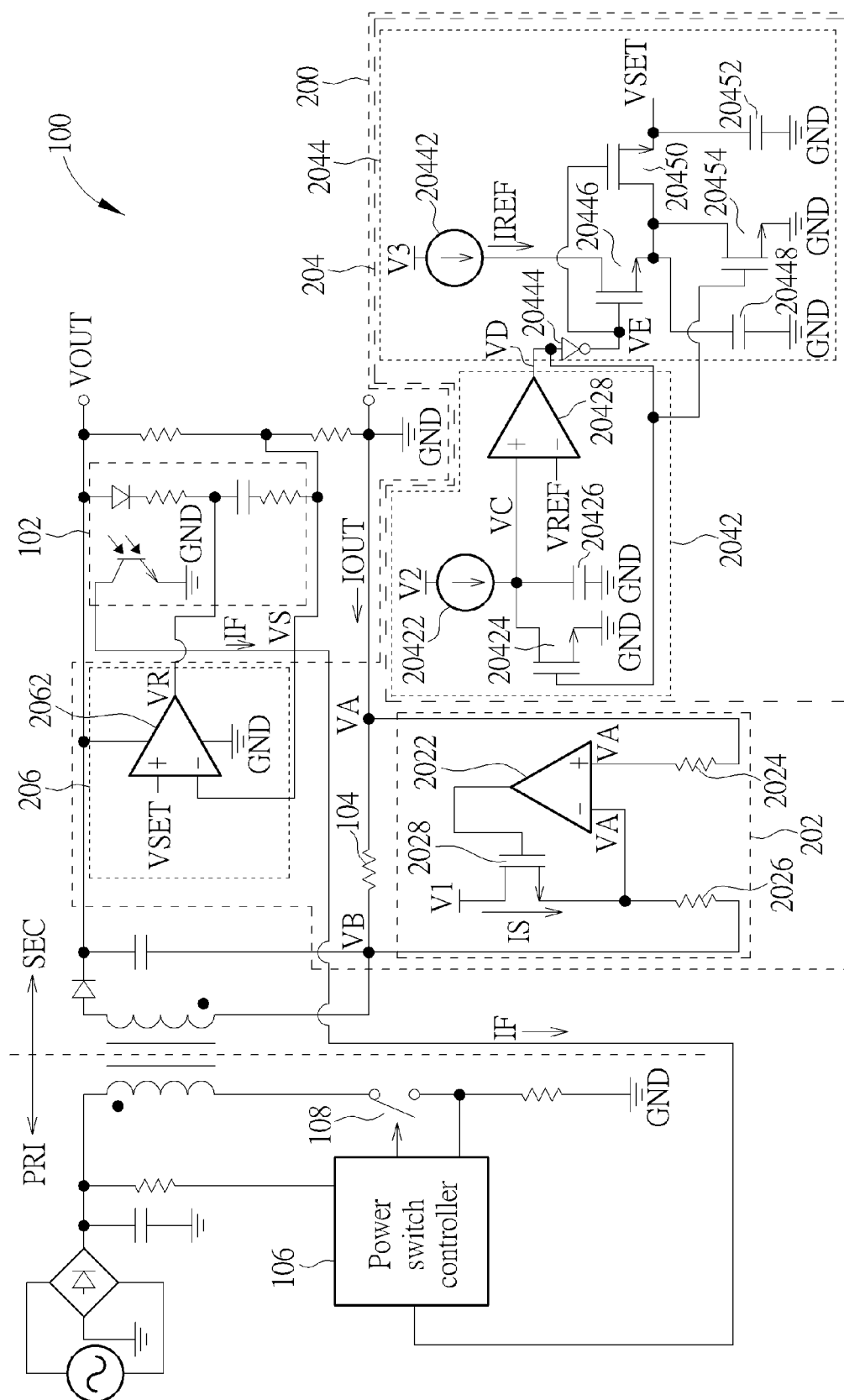


FIG. 1

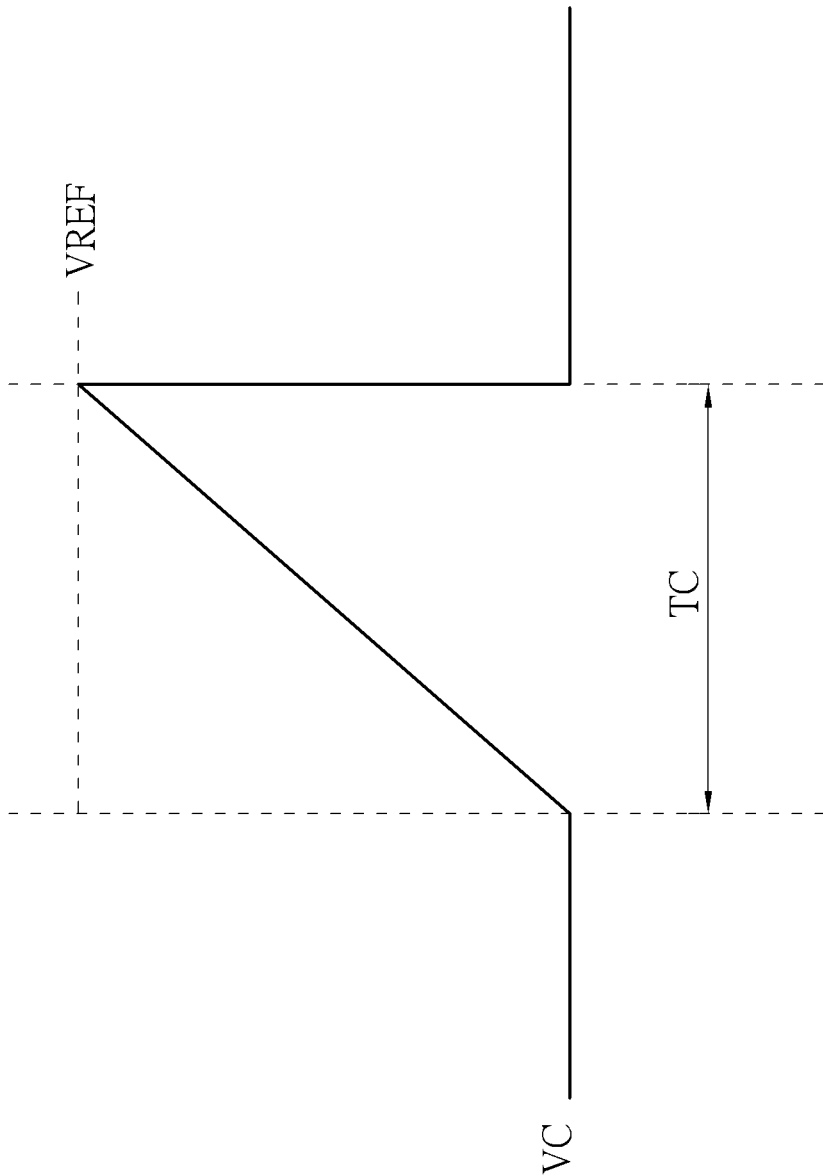


FIG. 2

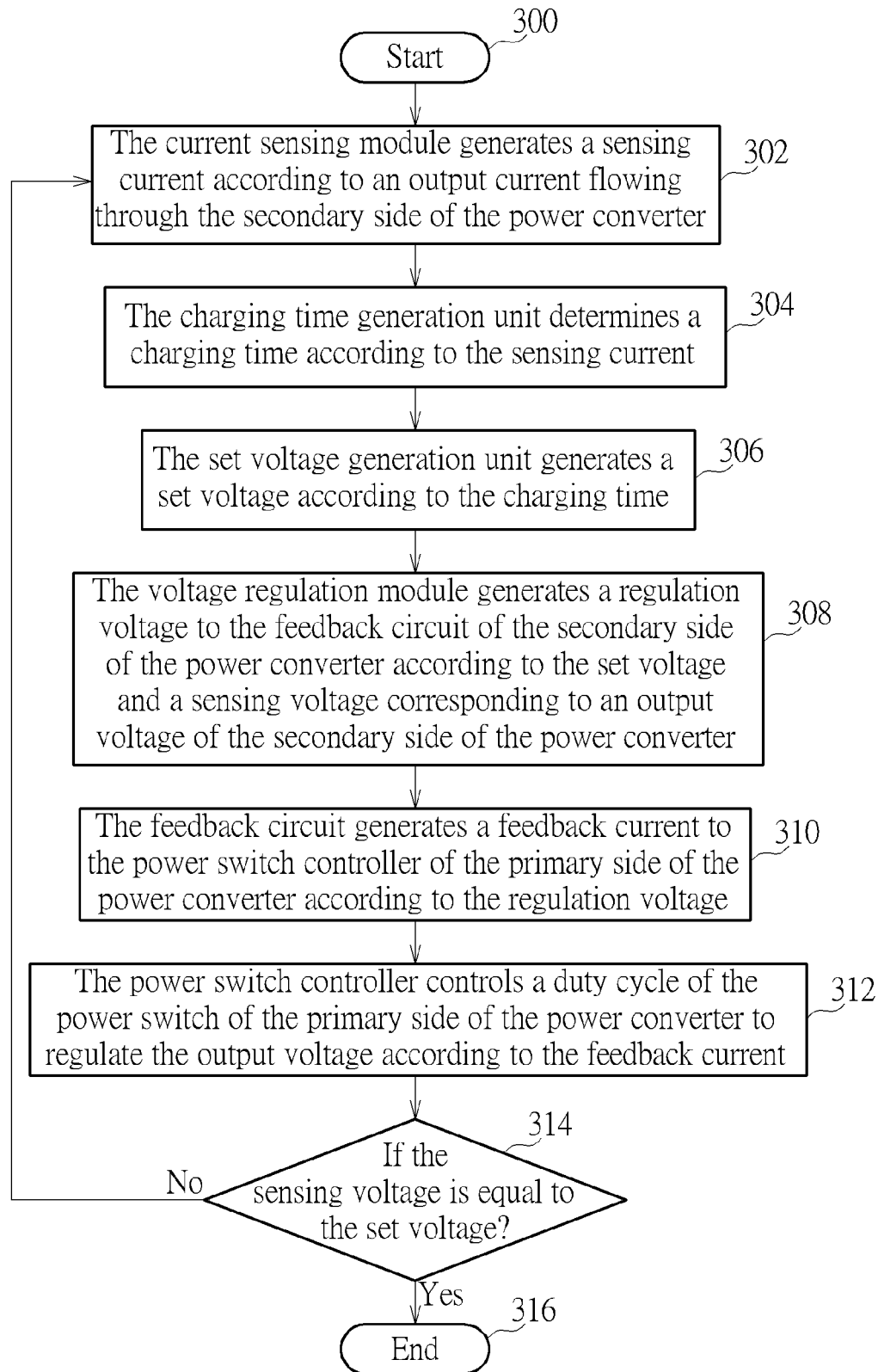


FIG. 3

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CONTROLLER FOR CONTROLLING A POWER CONVERTER TO OUTPUT CONSTANT POWER AND RELATED METHOD THEREOF

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 61/709,995, filed on Oct. 5, 2012 and entitled "Constant power for overload compensation," the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a controller for controlling a power converter to output constant power and a related method thereof, and particularly to a controller and a related method thereof that can control a power converter to output constant power through a secondary side of the power converter.

2. Description of the Prior Art

In the prior art, when a secondary side of a power converter is overload, an output current of the secondary side of the power converter can be increased to respond to overload of the secondary side of the power converter. Meanwhile, because the output current of the secondary side of the power converter is increased, a feedback current generated by a feedback circuit (e.g. a photo coupler) of the secondary side of the power converter is decreased, resulting in a power switch controller of a primary side of the power converter increasing a duty cycle of a power switch of the primary side of the power converter. Meanwhile, although the power switch controller of the primary side of the power converter has entered a deep continuous current mode (CCM), because the duty cycle of the power switch of the primary side of the power converter can not be increased infinitely in an over-current protection mode, the secondary side of the power converter cannot maintain a fixed output voltage, resulting in output power of the secondary side of the power converter being gradually decreased. In addition, the prior art can simultaneously control the output current and the output voltage of the secondary side of the power converter through a primary-side regulation constant current/constant voltage technology. However, in the primary-side regulation constant current/constant voltage technology, if the output current of the secondary side of the power converter exceeds a fixed current value, the output current of the secondary side of the power converter is still limited to the fixed current value, resulting in the output power of the secondary side of the power converter being still not maintained at a constant value. Therefore, when the secondary side of the power converter is overload, the output power of the secondary side of the power converter can not be maintained at a constant value, so a next stage circuit coupled to the secondary side of the power converter may not operate normally.

SUMMARY OF THE INVENTION

In view of the above mentioned problems of the prior art, the present invention provides a controller for controlling a power converter to output constant power and a related method thereof to control the power converter to output constant power.

An embodiment provides a controller for controlling a power converter to output constant power. The controller

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includes a current sensing module, a voltage generation module, and a voltage regulation module. The current sensing module is coupled to a secondary side of the power converter for generating a sensing current according to an output current flowing through the secondary side of the power converter. The voltage generation module is coupled to the current sensing module for generating a set voltage corresponding to a reciprocal of the sensing current according to the sensing current. The voltage regulation module is coupled to the voltage generation module and the secondary side of the power converter for generating a regulation voltage to a feedback circuit of the secondary side of the power converter according to the set voltage and a sensing voltage corresponding to an output voltage of the secondary side of the power converter, wherein the feedback circuit and a primary side of the power converter regulate the output voltage according to the regulation voltage. A product of the output voltage and the output current is a constant value.

Another embodiment provides a method for controlling a power converter to output constant power. The method provides generating a sensing current according to an output current flowing through a secondary side of the power converter; generating a set voltage corresponding to a reciprocal of the sensing current according to the sensing current; generating a regulation voltage to a feedback circuit of the secondary side of the power converter according to the set voltage and a sensing voltage corresponding to an output voltage of the secondary side of the power converter; and regulating the output voltage according to the regulation voltage. A product of the output voltage and the output current is a constant value.

The present invention provides a controller for controlling a power converter to output constant power and a related method thereof. The controller and the method utilize a current sensing module to generate a sensing current according to an output current flowing through a secondary side of the power converter, utilize a voltage generation module to generate a set voltage corresponding to a reciprocal of the sensing current according to the sensing current, and utilize a voltage regulation module to generate a regulation voltage to a feedback circuit of the secondary side of the power converter according to the set voltage and a sensing voltage corresponding to an output voltage of the secondary side of the power converter. Then, the feedback circuit and a primary side of the power converter can regulate the output voltage of the secondary side of the power converter according to the regulation voltage. Thus, the controller provided by the present invention and the feedback circuit of the secondary side of the power converter can repeat the above mentioned steps until the sensing voltage is equal to the set voltage. When the sensing voltage is equal to the set voltage, a product of the output voltage and the output current of the power converter is a constant value. Therefore, compared to the prior art, when the secondary side of the power converter is overload, the present invention can ensure that the output power of the secondary side of the power converter can be maintained at a constant value.

These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram illustrating a controller for controlling a power converter to output constant power according to an embodiment.

FIG. 2 is a diagram illustrating relationships between the charging time, a voltage of the first terminal of the first capacitor, and the reference voltage.

FIG. 3 is a flowchart illustrating a method for controlling a power converter to output constant power according to another embodiment.

DETAILED DESCRIPTION

Please refer to FIG. 1. FIG. 1 is a diagram illustrating a controller **200** for controlling a power converter **100** to output constant power according to an embodiment. As shown in FIG. 1, the controller **200** includes a current sensing module **202**, a voltage generation module **204**, and a voltage regulation module **206**. The current sensing module **202** generates a sensing current **IS** according to an output current **IOUT** flowing through a secondary side SEC of the power converter **100**. The voltage generation module **204** generates a set voltage **VSET** corresponding to a reciprocal of the sensing current **IS** according to the sensing current **IS**. The voltage regulation module **206** generates a regulation voltage **VR** to a feedback circuit **102** (e.g. a photo coupler module) of the secondary side SEC of the power converter **100** according to the set voltage **VSET** and a sensing voltage **VS** corresponding to an output voltage **VOUT** of the secondary side SEC of the power converter **100**, wherein the feedback circuit **102** and a primary side **PRI** of the power converter **100** regulate the output voltage **VOUT** according to the regulation voltage **VR**, and a product of the output voltage **VOUT** and the output current **IOUT** is a constant value. In addition, the sensing voltage **VS** is proportional to the output voltage **VOUT**. For example, the output voltage **VOUT** is **N** times to the sensing voltage **VS**, wherein **N** is a positive real number.

As shown in FIG. 1, the current sensing module **202** includes an operational amplifier **2022**, a first resistor **2024**, a second resistor **2026**, and a first metal-oxide-semiconductor transistor **2028**, wherein the first metal-oxide-semiconductor transistor **2028** is an N-type metal-oxide-semiconductor transistor. But, the present invention is not limited to the first metal-oxide-semiconductor transistor **2028** being an N-type metal-oxide-semiconductor transistor. The first resistor **2024** has a first terminal coupled to a first terminal of a sensing resistor **104** of the secondary side SEC of the power converter **100**, and a second terminal coupled to a first input terminal of the operational amplifier **2022**, wherein the output current **IOUT** flowing through the sensing resistor **104**. The second resistor **2026** has a first terminal coupled to a second terminal of the sensing resistor **104**, and a second terminal coupled to a second input terminal of the operational amplifier **2022**. The first metal-oxide-semiconductor transistor **2028** has a first terminal for receiving a first voltage **V1**, a second terminal coupled to an output terminal of the operational amplifier **2022**, and a third terminal coupled to the second input terminal of the operational amplifier **2022**.

When the operational amplifier **2022** operates normally, because a voltage of the first input terminal of the operational amplifier **2022** is equal to a voltage of the second input terminal of the operational amplifier **2022**, a voltage drop between the first input terminal of the second resistor **2026** and the second input terminal of the second resistor **2026** is equal to **VA-VB**, wherein the voltage of the first input terminal of the operational amplifier **2022** and the voltage of the second input terminal of the operational amplifier **2022** are equal to **VA**, and a voltage of the second terminal of the sensing resistor **104** is equal to **VB**. Therefore, the first metal-oxide-semiconductor transistor **2028** and the second resistor **2026** can generate the sensing current **IS** according to the

voltage drop (**VA-VB**) between the first input terminal of the second resistor **2026** and the second input terminal of the second resistor **2026** and equation (1):

$$IS = \frac{VA - VB}{R_{2026}} \quad (1)$$

As shown in equation (1), R_{2026} is a resistance of the second resistor **2026**. In addition, the output current **IOUT** can be determined according to equation (2):

$$IOUT = \frac{VA - VB}{R_{104}} \quad (2)$$

As shown in equation (2), R_{104} is a resistance of the sensing resistor **104**. As shown in equation (1) and equation (2), a relationship between the sensing current **IS** and the output current **IOUT** can be determined according to equation (3):

$$IS = \frac{R_{104}}{R_{2026}} \times IOUT = K \times IOUT \quad (3)$$

As shown in equation (3), **K** is equal to

$$\frac{R_{104}}{R_{2026}},$$

so the sensing current **IS** is proportional to the output current **IOUT** (**K**).

As shown in FIG. 1, the voltage generation module **204** includes a charging time generation unit **2042** and a set voltage generation unit **2044**, wherein the charging time generation unit **2042** is used for determining a charging time **TC** according to the sensing current **IS**. The set voltage generation unit **2044** is used for generating the set voltage **VSET** according to the charging time **TC**. The charging time generation unit **2042** includes a first current source **20422**, a second metal-oxide-semiconductor transistor **20424**, a first capacitor **20426**, and a first comparator **20428**. The first current source **20422** has a first terminal for receiving a second voltage **V2**, and a second terminal, wherein the first current source **20422** is used for mirroring and providing the sensing current **IS**, and the second voltage **V2** can be the same as or different from the first voltage **V1**. The second metal-oxide-semiconductor transistor **20424** has a first terminal coupled to the second terminal of the first current source **20422**, a second terminal, and a third terminal coupled to ground **GND**, wherein the second metal-oxide-semiconductor transistor **20424** is an N-type metal-oxide-semiconductor transistor. The first capacitor **20426** has a first terminal coupled to the second terminal of the first current source **20422**, and a second terminal coupled to the ground **GND**. The first comparator **20428** has a first input terminal coupled to the second terminal of the first current source **20422**, a second input terminal for receiving a reference voltage **VREF**, and an output terminal coupled to the second terminal of the second metal-oxide-semiconductor transistor **20424**, wherein the reference voltage **VREF** is used for setting output power of the secondary side SEC of the power converter **100**.

As shown in FIG. 1, the set voltage generation unit **2044** includes a second current source **20442**, an inverter **20444**, a

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third metal-oxide-semiconductor transistor **20446**, a second capacitor **20448**, a fourth metal-oxide-semiconductor transistor **20450**, a third capacitor **20452**, and a fifth metal-oxide-semiconductor transistor **20454**, wherein the fourth metal-oxide-semiconductor transistor **20450** and the fifth metal-oxide-semiconductor transistor **20454** are N-type metal-oxide-semiconductor transistors. But, the present invention is not limited to the fifth metal-oxide-semiconductor transistor **20454** being an N-type metal-oxide-semiconductor transistor. That is to say, the fifth metal-oxide-semiconductor transistor **20454** can also be a P-type metal-oxide-semiconductor transistor or a transmission gate. The second current source **20442** has a first terminal for receiving a third voltage **V3**, and a second terminal, wherein the second current source **20442** is used for providing a reference current **IREF**, and the first voltage **V1**, the second voltage **V2**, and the third voltage **V3** can be the same or different. The inverter **20444** has a first terminal coupled to the output terminal of the first comparator **20428**, and a second terminal. The third metal-oxide-semiconductor transistor **20446** has a first terminal coupled to the second terminal of the second current source **20442**, a second terminal coupled to the second terminal of the inverter **20444**, and a third terminal. The second capacitor **20448** has a first terminal coupled to the third terminal of the third metal-oxide-semiconductor transistor **20446**, and a second terminal coupled to the ground **GND**. The fourth metal-oxide-semiconductor transistor **20450** has a first terminal coupled to the first terminal of the second capacitor **20448**, a second terminal coupled to the second terminal of the inverter **20444**, and a third terminal. The third capacitor **20452** has a first terminal coupled to the third terminal of the fourth metal-oxide-semiconductor transistor **20450**, and a second terminal coupled to the ground **GND** for outputting the set voltage **VSET**. The fifth metal-oxide-semiconductor transistor **20454** has a first terminal coupled to the first terminal of the second capacitor **20448**, a second terminal coupled to the first terminal of the inverter **20444**, and a third terminal coupled to the ground **GND**. In addition, when the fifth metal-oxide-semiconductor transistor **20454** is a P-type metal-oxide-semiconductor transistor or a transmission gate, a coupled method corresponding to the fifth metal-oxide-semiconductor transistor **20454** is different from a coupled method corresponding to the fifth metal-oxide-semiconductor transistor **20454** shown in FIG. 1, and will be modified accordingly.

As shown in FIG. 1, the voltage regulation module **206** includes a second comparator **2062**. The second comparator **2062** has a first input terminal coupled to the third terminal of the fourth metal-oxide-semiconductor transistor **20450**, a second input terminal for receiving the sensing voltage **VS**, and an output terminal for outputting the regulation voltage **VR** to the feedback circuit **102**, wherein the feedback circuit **102** is used for generating a feedback current **IF** to a power switch controller **106** of the primary side **PRI** of the power converter **100** according to the regulation voltage **VR**.

Please refer to FIG. 2. FIG. 2 is a diagram illustrating relationships between the charging time **TC**, a voltage **VC** of the first terminal of the first capacitor **20426**, and the reference voltage **VREF**. As shown in FIG. 1, when the secondary side **SEC** of the power converter **100** is overload, the output current **IOUT** of the secondary side **SEC** of the power converter **100** can be increased to respond to overload of the secondary side **SEC** of the power converter **100**. Meanwhile, because the output current **IOUT** of the secondary side **SEC** of the power converter **100** is increased, the sensing current **IS** generated by the current sensing module **202** according to the output current **IOUT** is also increased as shown in equation (3).

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As shown in FIG. 1 and FIG. 2, when the charging time generation unit **2042** starts to operate, the sensing current **IS** starts to charge the first capacitor **20426**. Because the voltage **VC** of the first terminal of the first capacitor **20426** is less than the reference voltage **VREF**, a voltage **VD** of the output terminal of the first comparator **20428** is low, resulting in the second metal-oxide-semiconductor transistor **20424** being turned off. Therefore, the voltage **VC** of the first terminal of the first capacitor **20426** is gradually increased until the voltage **VC** of the first terminal of the first capacitor **20426** is greater than the reference voltage **VREF**. When the voltage **VC** of the first terminal of the first capacitor **20426** is greater than the reference voltage **VREF**, because the voltage **VD** of the output terminal of the first comparator **20428** is high, the second metal-oxide-semiconductor transistor **20424** is turned on, resulting in the voltage **VC** of the first terminal of the first capacitor **20426** being decreased. In addition, the second metal-oxide-semiconductor transistor **20424** can be designed to let the voltage **VC** of the first terminal of the first capacitor **20426** be quickly reduced to zero. Therefore, As shown in FIG. 2, the charging time **TC** determined by the charging time generation unit **2042** is a charging time of the first capacitor **20426** (that is, the charging time **TC** is changed with the sensing current **IS**), wherein the first capacitor **20426**, the reference voltage **VREF**, and the sensing current **IS** can determine the charging time **TC** according to equation (4):

$$TC = \frac{C_{20426} \times VREF}{IS} \quad (4)$$

As shown in equation (4), C_{20426} is a capacitance of the first capacitor **20426**.

As shown in FIG. 1 and FIG. 2, during the charging time **TC** (the voltage **VC** of the first terminal of the first capacitor **20426** is less than the reference voltage **VREF**), the voltage **VD** of the output terminal of the first comparator **20428** is low, so a voltage **VE** of the second terminal of the inverter **20444** is high. Therefore, during the charging time **TC**, the fifth metal-oxide-semiconductor transistor **20454** is turned off, the third metal-oxide-semiconductor transistor **20446** is turned on, and the fourth metal-oxide-semiconductor transistor **20450** is turned on. When the fifth metal-oxide-semiconductor transistor **20454** is turned off, the third metal-oxide-semiconductor transistor **20446** is turned on, and the fourth metal-oxide-semiconductor transistor **20450** is turned on, the second current source **20442** charges the second capacitor **20448** and the third capacitor **20452** according to the reference current **IREF**, wherein the reference current **IREF**, the second capacitor **20448**, the third capacitor **20452**, and the charging time **TC** can determine the set voltage **VSET** according to equation (4) and equation (5):

$$VSET = \frac{IREF \times C_{20426} \times VREF}{(C_{20448} + C_{20452}) \times IS} \quad (5)$$

As shown in equation (5), C_{20448} is a capacitance of the second capacitor **20448** and C_{20452} is a capacitance of the third capacitor **20452**. As shown in equation (5), the reference voltage **VREF**, the reference current **IREF**, the capacitance of the first capacitor **20426**, the capacitance of the second capacitor **20448**, and the capacitance of the third capacitor **20452** are known, so the set voltage **VSET** corresponds to a reciprocal of the sensing current **IS**, that is, the set voltage **VSET** is inverse proportion to the sensing current **IS**.

In addition, when the voltage VC of the first terminal of the first capacitor **20426** is greater than the reference voltage VREF, because the voltage VD of the output terminal of the first comparator **20428** is high, the fifth metal-oxide-semiconductor transistor **20454** is turned on, the third metal-oxide-semiconductor transistor **20446** is turned off, and the fourth metal-oxide-semiconductor transistor **20452** is turned off, resulting in a voltage of the first terminal of the second capacitor **20448** being decreased. In addition, the fifth metal-oxide-semiconductor transistor **20454** can be designed to let the voltage of the first terminal of the second capacitor **20448** be quickly reduced to zero.

After the set voltage generation unit **2044** generates the set voltage VSET according to the charging time TC, if the sensing voltage VS is less than the set voltage VSET, the regulation voltage VR generated by the voltage regulation module **206** is high, resulting in the feedback circuit **102** generating the smaller feedback current IF to the power switch controller **106** of the primary side PRI of the power converter **100** according to the regulation voltage VR. Therefore, the power switch controller **106** can regulate a duty cycle of the power switch **108** of the primary side PRI of the power converter **100** to increase the sensing voltage VS (because the sensing voltage VS is proportional to the output voltage VOUT) according to the smaller feedback current IF. If the sensing voltage VS is still less than the set voltage VSET, the controller **200** can repeat the above mentioned steps until the sensing voltage VS is equal to the set voltage VSET.

A product of the set voltage VSET and the sensing current IS is generated by rewriting equation (5):

$$VSET \times IS = \frac{IREF \times C_{20426} \times VREF}{(C_{20448} + C_{20452})} \quad (6)$$

Substituting the output voltage VOUT and the output current IOUT into equation (6) yields equation (7):

$$VOUT \times IOUT = \frac{IREF \times C_{20426} \times VREF}{(C_{20448} + C_{20452})} \times \frac{N}{K} \quad (7)$$

As shown in equation (7), the product of the output voltage VOUT and the output current IOUT is a constant value, so the controller **200** can control the power converter **100** to output constant power.

Please refer to FIG. 1, FIG. 2, and FIG. 3. FIG. 3 is a flowchart illustrating a method for controlling a power converter to output constant power according to another embodiment. The method in FIG. 3 is illustrated using the controller **200** in FIG. 1. Detailed steps are as follows:

Step **300**: Start.

Step **302**: The current sensing module **202** generates a sensing current IS according to an output current IOUT flowing through the secondary side SEC of the power converter **100**.

Step **304**: The charging time generation unit **2042** determines a charging time TC according to the sensing current IS.

Step **306**: The set voltage generation unit **2044** generates a set voltage VSET according to the charging time TC.

Step **308**: The voltage regulation module **206** generates a regulation voltage VR to the feedback circuit **102** of the secondary side SEC of the power converter **100** according to the set voltage VSET and a sensing voltage VS corresponding to an output voltage VOUT of the secondary side SEC of the power converter **100**.

Step **310**: The feedback circuit **102** generates a feedback current IF to the power switch controller **106** of the primary side PRI of the power converter **100** according to the regulation voltage VR.

Step **312**: The power switch controller **106** controls a duty cycle of the power switch **108** of the primary side PRI of the power converter **100** to regulate the output voltage VOUT according to the feedback current IF.

Step **314**: If the sensing voltage VS is equal to the set voltage VSET; if yes, go to Step **316**; if no, go to Step **302**.

Step **316**: End.

In Step **302**, as shown in FIG. 1, when the operational amplifier **2022** operates normally, because a voltage of the first input terminal of the operational amplifier **2022** is equal to a voltage of the second input terminal of the operational amplifier **2022**, a voltage drop between the first input terminal of the second resistor **2026** and the second input terminal of the second resistor **2026** is equal to VA-VB, wherein the voltage of the first input terminal of the operational amplifier **2022** and the voltage of the second input terminal of the operational amplifier **2022** are equal to VA, and a voltage of the second terminal of the sensing resistor **104** is equal to VB. Therefore, the current sensing module **202** can generate the sensing current IS according to the voltage drop (VA-VB) between the first input terminal of the second resistor **2026** and the second input terminal of the second resistor **2026** and equation (1), wherein the sensing current IS is proportional to the output current IOUT (K) as shown in equation (3).

In Step **304**, as shown in FIG. 1 and FIG. 2, when the charging time generation unit **2042** starts to operate, the sensing current IS starts to charge the first capacitor **20426**. Because a voltage VC of the first terminal of the first capacitor **20426** is less than the reference voltage VREF, a voltage VD of the output terminal of the first comparator **20428** is low, resulting in the second metal-oxide-semiconductor transistor **20424** being turned off. Therefore, the voltage VC of the first terminal of the first capacitor **20426** is gradually increased until the voltage VC of the first terminal of the first capacitor **20426** is greater than the reference voltage VREF. When the voltage VC of the first terminal of the first capacitor **20426** is greater than the reference voltage VREF, because the voltage VD of the output terminal of the first comparator **20428** is high, the second metal-oxide-semiconductor transistor **20424** is turned on, resulting in the voltage VC of the first terminal of the first capacitor **20426** being decreased. In addition, the second metal-oxide-semiconductor transistor **20424** can be designed to let a discharging current flowing through the second metal-oxide-semiconductor transistor **20424** to the ground GND is much greater than the sensing current IS. Thus, the voltage VC of the first terminal of the first capacitor **20426** can be quickly reduced to zero. Therefore, as shown in FIG. 2, the charging time TC determined by the charging time generation unit **2042** is a charging time of the first capacitor **20426**, wherein the first capacitor **20426**, the reference voltage VREF, and the sensing current IS can determine the charging time TC according to equation (4).

In Step **306**, as shown in FIG. 1 and FIG. 2, during the charging time TC (the voltage VC of the first terminal of the first capacitor **20426** is less than the reference voltage VREF), the voltage VD of the output terminal of the first comparator **20428** is low, so a voltage VE of the second terminal of the inverter **20444** is high. Therefore, during the charging time TC, the fifth metal-oxide-semiconductor transistor **20454** is turned off, the third metal-oxide-semiconductor transistor **20446** is turned on, and the fourth metal-oxide-semiconductor transistor **20450** is turned on. When the fifth metal-oxide-semiconductor transistor **20454** is turned off, the third metal-

oxide-semiconductor transistor **20446** is turned on, and the fourth metal-oxide-semiconductor transistor **20450** is turned on, the second current source **20442** charges the second capacitor **20448** and the third capacitor **20452** according to a reference current IREF, wherein the reference current IREF, the second capacitor **20448**, the third capacitor **20452**, and the charging time TC can determine the set voltage VSET according to equation (4) and equation (5). As shown in equation (5), the reference voltage VREF, the reference current IREF, a capacitance of the first capacitor **20426**, a capacitance of the second capacitor **20448**, and a capacitance of the third capacitor **20452** are known, so the set voltage VSET corresponds to a reciprocal of the sensing current IS, that is, the set voltage VSET is inverse proportion to the sensing current IS.

In addition, when the voltage VC of the first terminal of the first capacitor **20426** is greater than the reference voltage VREF, because the voltage VD of the output terminal of the first comparator **20428** is high, the fifth metal-oxide-semiconductor transistor **20454** is turned on, the third metal-oxide-semiconductor transistor **20446** is turned off, and the fourth metal-oxide-semiconductor transistor **20452** is turned off, resulting in a voltage of the first terminal of the second capacitor **20448** being decreased. In addition, the fifth metal-oxide-semiconductor transistor **20454** can be designed to let the voltage of the first terminal of the second capacitor **20448** be quickly reduced to zero.

In Step **308** and Step **310**, after the set voltage generation unit **2044** generates the set voltage VSET according to the charging time TC, if the sensing voltage VS is less than the set voltage VSET, the regulation voltage VR generated by the voltage regulation module **206** is high, resulting in the feedback circuit **102** generating the smaller feedback current IF to the power switch controller **106** of the primary side PRI of the power converter **100** according to the regulation voltage VR.

In Step **312**, the power switch controller **106** can regulate the duty cycle of the power switch **108** of the primary side PRI of the power converter **100** to increase the sensing voltage VS (because the sensing voltage VS is proportional to the output voltage VOUT) according to the smaller feedback current IF. If the sensing voltage VS is still less than the set voltage VSET, the controller **200** can repeat the above mentioned steps until the sensing voltage VS is equal to the set voltage VSET. In addition, as shown in equation (7), a product of the output voltage VOUT and the output current IOUT is a constant value, so the controller **200** can control the power converter **100** to output constant power.

To sum up, the controller for controlling the power converter to output constant power and the method for controlling the power converter to output constant power utilize the current sensing module to generate a sensing current according to an output current flowing through the secondary side of the power converter, utilize the voltage generation module to generate a set voltage corresponding to a reciprocal of the sensing current according to the sensing current, and utilize the voltage regulation module to generate a regulation voltage to the feedback circuit of the secondary side of the power converter according to the set voltage and a sensing voltage corresponding to an output voltage of the secondary side of the power converter. Then, the feedback circuit and the primary side of the power converter can regulate the output voltage of the secondary side of the power converter according to the regulation voltage. Thus, the controller provided by the present invention and the feedback circuit of the secondary side of the power converter can repeat the above mentioned steps until the sensing voltage is equal to the set voltage. When the sensing voltage is equal to the set voltage, a product of the output voltage and the output current of the power converter is a constant value. Therefore, compared to the prior art, when the secondary side of the power converter

is overload, the present invention can ensure that the output power of the secondary side of the power converter can be maintained at a constant value.

Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

What is claimed is:

1. A controller for controlling a power converter to output constant power, the controller comprising:

a current sensing module coupled to a secondary side of the power converter for generating a sensing current according to an output current flowing through the secondary side of the power converter;

a voltage generation module coupled to the current sensing module for generating a set voltage corresponding to a reciprocal of the sensing current according to the sensing current; and

a voltage regulation module coupled to the voltage generation module and the secondary side of the power converter for generating a regulation voltage to a feedback circuit of the secondary side of the power converter according to the set voltage and a sensing voltage corresponding to an output voltage of the secondary side of the power converter, wherein the feedback circuit and a primary side of the power converter regulate the output voltage according to the regulation voltage;

wherein a product of the output voltage and the output current is a constant value.

2. The controller of claim 1, wherein the sensing current is proportional to the output current.

3. The controller of claim 1, wherein the current sensing module comprises:

an operational amplifier;

a first resistor having a first terminal coupled to a first terminal of a sensing resistor of the secondary side of the power converter, and a second terminal coupled to a first input terminal of the operational amplifier, wherein the output current flows through the sensing resistor;

a second resistor having a first terminal coupled to a second terminal of the sensing resistor, and a second terminal coupled to a second input terminal of the operational amplifier; and

a first metal-oxide-semiconductor transistor having a first terminal for receiving a first voltage, a second terminal coupled to an output terminal of the operational amplifier, and a third terminal coupled to the second input terminal of the operational amplifier;

wherein the first metal-oxide-semiconductor transistor and the second resistor generates the sensing current according to a voltage drop between the first terminal of the second resistor and the second terminal of the second resistor.

4. The controller of claim 1, wherein the voltage generation module comprises:

a charging time generation unit for determining a charging time according to the sensing current; and

a set voltage generation unit for generating the set voltage according to the charging time.

5. The controller of claim 4, wherein

the charging time generation unit comprises:

a first current source having a first terminal for receiving a second voltage, and a second terminal, wherein the first current source is used for mirroring and providing the sensing current;

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a second metal-oxide-semiconductor transistor having a first terminal coupled to the second terminal of the first current source, a second terminal, and a third terminal coupled to ground;

a first capacitor having a first terminal coupled to the second terminal of the first current source, and a second terminal coupled to the ground; and a first comparator having a first input terminal coupled to the second terminal of the first current source, a second input terminal for receiving a reference voltage, and an output terminal coupled to the second terminal of the second metal-oxide-semiconductor transistor, wherein the sensing current, the first capacitor, and the reference voltage are used for determining the charging time; and

the set voltage generation unit comprises:

a second current source having a first terminal for receiving a third voltage, and a second terminal, wherein the second current source is used for providing a reference current;

an inverter having a first terminal coupled to the output terminal of the first comparator, and a second terminal;

a third metal-oxide-semiconductor transistor having a first terminal coupled to the second terminal of the second current source, a second terminal coupled to the second terminal of the inverter, and a third terminal;

a second capacitor having a first terminal coupled to the third terminal of the third metal-oxide-semiconductor transistor, and a second terminal coupled to the ground;

a fourth metal-oxide-semiconductor transistor having a first terminal coupled to the first terminal of the second capacitor, a second terminal coupled to the second terminal of the inverter, and a third terminal;

a third capacitor having a first terminal coupled to the third terminal of the fourth metal-oxide-semiconductor transistor, and a second terminal coupled to the ground for outputting the set voltage; and

a fifth metal-oxide-semiconductor transistor having a first terminal coupled to the first terminal of the second capacitor, a second terminal coupled to the output terminal of the first comparator, and a third terminal coupled to the ground;

wherein the reference current, the second capacitor, the third capacitor, and the charging time are used for determining the set voltage.

6. The controller of claim 5, wherein when a voltage of the first terminal of the first capacitor is less than or equal to the reference voltage, the second metal-oxide-semiconductor transistor is turned off, the fifth metal-oxide-semiconductor transistor is turned off, the third metal-oxide-semiconductor transistor is turned on, and the fourth metal-oxide-semiconductor transistor is turned on.

7. The controller of claim 6, wherein when the second metal-oxide-semiconductor transistor is turned off, the fifth metal-oxide-semiconductor transistor is turned off, the third metal-oxide-semiconductor transistor is turned on, and the fourth metal-oxide-semiconductor transistor is turned on, the

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first current source charges the first capacitor, and the second current source charges the second capacitor and the third capacitor.

8. The controller of claim 5, wherein when a voltage of the first terminal of the first capacitor is greater than the reference voltage, the second metal-oxide-semiconductor transistor is turned on, the fifth metal-oxide-semiconductor transistor is turned on, the third metal-oxide-semiconductor transistor is turned off, and the fourth metal-oxide-semiconductor transistor is turned off.

9. The controller of claim 5, wherein the voltage regulation module comprises:

a second comparator having a first input terminal coupled to the third terminal of the fourth metal-oxide-semiconductor transistor, a second input terminal for receiving the sensing voltage, and an output terminal for outputting the regulation voltage to the feedback circuit, wherein the feedback circuit is used for generating a feedback current to a power switch controller of the primary side of the power converter according to the regulation voltage.

10. The controller of claim 9, wherein the power switch controller controls a duty cycle of a power switch of the primary side of the power converter to regulate the output voltage according to the feedback current.

11. A method for controlling a power converter to output constant power, the method comprising:

generating a sensing current according to an output current flowing through a secondary side of the power converter; generating a set voltage corresponding to a reciprocal of the sensing current according to the sensing current; generating a regulation voltage to a feedback circuit of the secondary side of the power converter according to the set voltage and a sensing voltage corresponding to an output voltage of the secondary side of the power converter; and regulating the output voltage according to the regulation voltage;

wherein a product of the output voltage and the output current is a constant value.

12. The method of claim 11, wherein the sensing current is proportional to the output current.

13. The method of claim 11, wherein generating the set voltage corresponding to the reciprocal of the sensing current according to the sensing current comprises:

determining a charging time according to the sensing current; and generating the set voltage according to the charging time.

14. The method of claim 11, wherein regulating the output voltage according to the regulation voltage comprises:

generating a feedback current to a power switch controller of a primary side of the power converter according to the regulation voltage; and

controlling a duty cycle of a power switch of the primary side of the power converter to regulate the output voltage according to the feedback current.

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